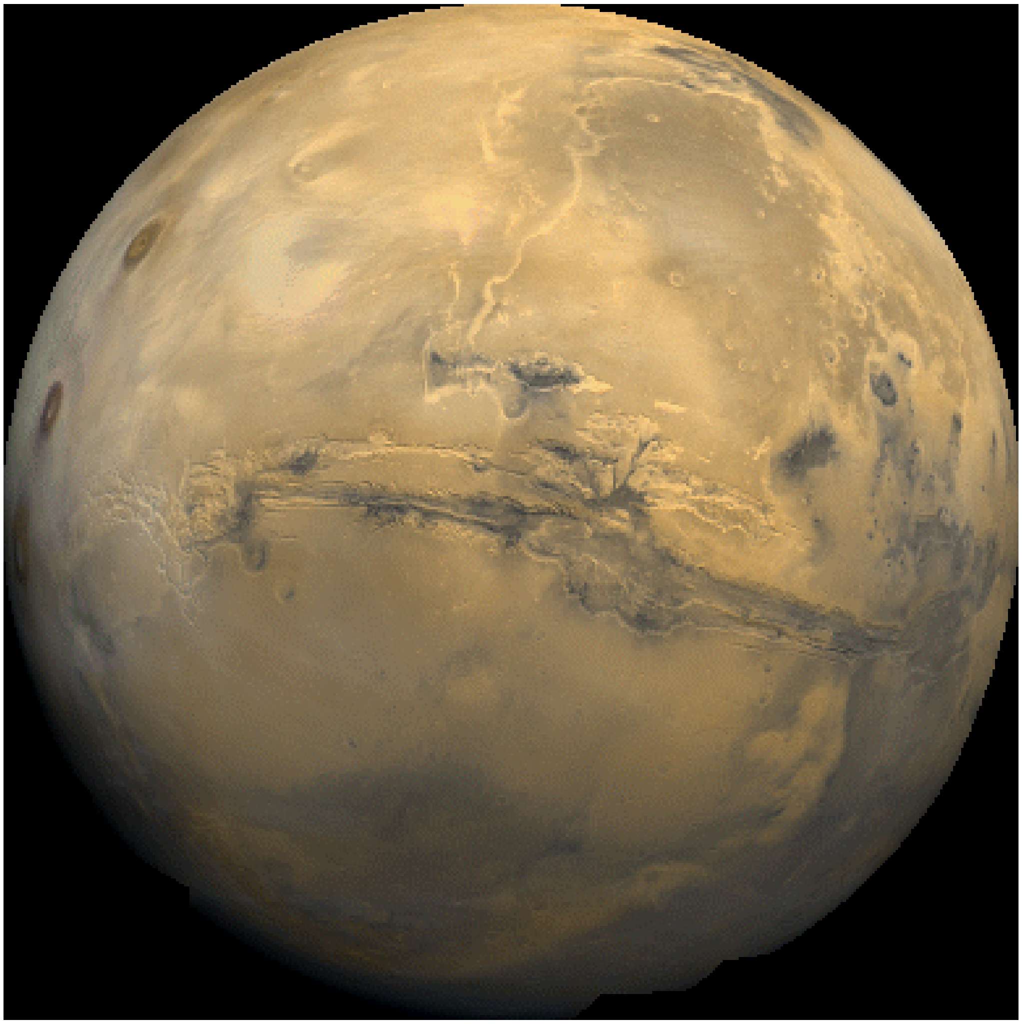
MARS



Lesson 1 - Roving on the Red Planet

Roving on the Red Planet

Grade Level: 5th-9th

Objectives:
- Operation of a robotic vehicle without direct observation or contact
- Understanding how remote robotic rovers are operated
- Conversion of mathematical units of time and distance

Arizona State Standards:
- **1SC-P2.** Compare observations of the real world to observations of a constructed model. **PO 1**. Assess the capability of a model to represent a "real world" scenario.
- **1SC-P6. PO 3**. Analyze experimental data.

Time Needed: 2 class periods

Background:
Robotic vehicles, such as the Sojourner Truth **rover** of the Pathfinder mission to Mars, are being incorporated into many planetary space missions to act as robotic scientists since humans cannot yet explore other planetary surfaces first hand. Scientists back on Earth control these rovers by sending commands via radio waves that travel at the speed of light (186,000 miles/second). It takes some time for these signals to reach the rover because they have to travel all the way from Earth out to other planets. For example, it takes light from the sun 8½ minutes to reach Earth, a distance of approximately 150,000,000 kilometers. It takes about 12 minutes for radio signals moving at the speed of light to travel from Earth to Mars. The exact time depends on the actual distance between the planets at a given time in their orbits.

Because it takes several minutes for the rovers to receive their commands, controllers need to anticipate speed and direction. Say you are a mission scientist and send a command to the Mars rover telling it to start moving forward. In 12 minutes the rover will start moving forward. If you want the rover to stop moving 15 minutes after it starts, when would you send the stop command? You would send the stop command 3 minutes after you sent the start command. You also need to consider how long it takes the rover to come to a complete stop and add that to the time needed for the rover to receive the signal. So you see there is a lot of planning that must go into guiding the rover correctly. To keep rovers out of trouble, NASA has designed "Smart Rovers" with artificial intelligence to help guide them. To avoid complications, rover drivers view the landing site using Virtual Reality goggles and design all the commands ahead of time sending an entire command package to the rover's computer. The rover then carries out its orders, hopefully without running into any unwanted obstacles.

Materials:

- Remote control car or rover
- Measuring devices (meter, yard stick or tape measure); 2 per team
- Rocks or other objects to use as **"waypoints";** to which to drive the car or rover
- Stopwatches
- Popsicle sticks (provided)
- Pencils
- Masking tape for start and finish lines
- Calculators

Procedure:

1. Divide the class into groups (teams) of four to six students.
2. Chose a *test driver* and a ***calibration** driver* for each team. These drivers should not see the course. They can be taken to another room or area blind to the course.
3. Other members of the team (*course calibration team*) will set up a rover course outlined with Popsicle sticks and use rocks or other objects as targets or waypoints to which the rover will navigate.
4. While the *course calibrators* are setting up the course, the *calibration driver* (with the *test driver* helping) will calibrate the rover for the following and record measurements on the ***Rover Calibration Sheet***:
   a. Distance traveled in 5 seconds (3 trials)
   b. Time needed to turn in 45° increments, a full 360º
   c. Time needed for a complete stop
   d. Any other tests that the students can create
5. Have each *course calibration team* measure the distance to each waypoint on the course and record it on the ***Course Calibration Sheet***.
6. Next, have the course calibration teams measure the turn angle needed to point the rover toward each waypoint. The turns should be in 45° increments for easier measurement.
7. Once all the data is recorded, each team will meet (away from the course) to create a mission plan. Enter the data needed to operate the rover along the course onto the ***Rover Mission Plan***. Use the ***Course Calibration Sheet*** and the ***Rover Calibration Sheet*** to convert the distance and angle measurements into time intervals for each waypoint destination. For example: if the course calibration team measured 2 meters to the first target and the rover was calibrated at traveling 1 meter in 3 seconds, then the time to the first target should be 6 seconds. Use the same procedure to determine the time it takes to turn a given number of degrees. An example will look like this: 12 seconds straight; stop; left 45°, 10 seconds straight; stop; right 90°, stop.
8. Once all the data is calculated, the course calibrators will place the rover at the starting line of the course. The test driver, who still cannot see the course, will drive the team vehicle according to mission plan calculations. The calibration driver will read the commands to the test driver while another team member times the movements of the rover. After each traverse made by the rover, a course calibration team member will measure how far the rover moved and record it on the ***Experiment Analysis Sheet***. Each student will be responsible for filling out his or her own sheet.

9. After each team has completed the course, the actual traverse results are compared with the calibrated measurements and recorded on the ***Experiment Analysis Sheet***. Each team will be given time to determine what kind of adjustments are needed to drive the rover more accurately. At this point the course can be driven again or the class can participate in a discussion on what they might have done differently and how to improve their results.

Assessment:
Students' calibration sheets, mission plans, and analysis sheets can be turned in. A grade can also be given for team participation.

Closure:
Have the students explore the following websites on Mars Rovers:

The Athena Rover Homepage: Mars Sample return mission –
http://athena.cornell.edu

LAPIS Student Rover Mission: FIDO Rover –
http://fido.jpl.nasa.gov

Mars Pathfinder Mission: Sojourner Truth Rover –
http://mpfwww.jpl.nasa.gov/MPF/mpf/rover-ops.html

Vocabulary:
Rover, waypoints, calibration

Reference:
"Out of sight" Remote Vehicle Activity. Mars Activities: Teacher Resources and Classroom Activities; Arizona State University, Mars K-12 Education Program.

Additional Resources:
http://mars.jpl.nasa.gov/missions/future/2003.html
http://robotics.jpl.nasa.gov/
http://www.planetary.org/rrgtm/mer-rovers.html
http://www.nasm.si.edu/ceps/etp/tools/tools_rover.html

Rover Calibration Sheet

Team Name______________________ Your Name________________________

Calibration Tests:
Using a stopwatch and a meter stick, yard stick, or measuring tape record the time and distance of the rover during the tests. All measurements should be taken the same way every time for accuracy.

Distance rover travels in 5 seconds

TRIAL	DISTANCE (in meters or feet)
#1	
#2	
#3	

Calculate average distance:

Trial #1
Trial #2
+ Trial #3

☐ / 3 = ____________(Average distance/5 seconds)

To calculate how far the rover travels in 1 second, divide the Average distance/5 seconds by 5.

☐ = Average distance/second

Rover Turn Time

ANGLE IN DEGREES	SECONDS TO COMPLETE TURN
45º	
90º	
135º	
180º	
225º	
270º	
315º	
360º	

TIME NEEDED FOR A COMPLETE STOP _________________ SECONDS

Invent your own test:

Course Calibration Sheet

Team Name______________________ Your Name________________________

First you must work with members of all course calibration teams to design a symmetrical rover course. Use the popsicle sticks to outline your course and make a start and finish line using the masking tape. Then, using a meter stick, yardstick, or measuring tape, record the distance to each waypoint. Calculate the turn angles the rover will make to line up straight with the next waypoint. All measurements should be taken the same way every time for accuracy.

Course Calibration Chart

WAYPOINT	DISTANCE (meters or feet)	TURN ANGLE
#1		
#2		
#3		
#4		
#5		
#6		

Sketch a diagram of the course below:

Rover Mission Plan

Team Name____________________ Your Name______________________

Directions: Using the data from the Rover and the Course Calibration Sheets design a mission plan to get your rover to each of the waypoints and to the end of the course. Use the average speed (meters/second) and the measured course distance to plan how long your rover will run in each direction and how much time is needed to turn your rover the right distance so it can reach the next waypoint.

Mission Plan Chart

Waypoint #	Distance to waypoint	Time it will take rover to reach waypoint	Angle to turn to reach next waypoint	Time its takes rover to turn in the direction of the next waypoint
#1				
#2				
#3				
#4				
#5				
#6				
Finish				

Experiment Analysis Sheet

Team Name_____________________ Your Name_______________________

Fill in the chart with the data your team collected and answer the questions below it.

Waypoint #	Actual measurements to waypoints	Actual distance traveled by rover	Difference in measurements
#1			
#2			
#3			
#4			
#5			
#6			
FINISH			

Questions:

1. Did your actual test results differ from the initial calibrated distances? If so, how?

2. How does operating a rover in this way differ from being able to directly view the rover while driving it?

3. What changes could you have made that would give you more accurate results?

4. What did you think of this lesson? Would you have done it a different way?